Ergonomic interventions in the shop-floor workstations of selected local manufacturing units

Synopsis

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Introduction

Ergonomics is the application of physiological, biomechanical, or psychophysical principles to the engineering and design of products, processes, and systems. The primary objectives of ergonomics are to reduce human error, increase productivity, and enhance safety, system availability and comfort with an emphasis on the interaction between the human and the system. In other words, ergonomics focuses on the application of human-system interface technology to the design or modification of systems to improve quality of life. Musculoskeletal disorders (MSDs), one of the most common work-related disorders, may develop in different parts of the human body during work. These appear in the lower back and upper extremities most commonly [1]. Physical factors (e.g., repeated movements, awkward postures, heavy load, etc.) and organizational factors (e.g., faster work rate, difficult-to-meet schedule etc.) contribute to MSDs. These not only have health related consequences for the workers, but also affect the production schedule and the economy of business adversely [2].

To prevent the development of MSDs, it is necessary to identify work-related ergonomics risk factors (WERFs) that occur during work. Once identified, measures can be taken to prevent or lessen them [3]. These measures include job-rotation [4], ergonomic training to workers [5], and redesigning work stations [6]. WERFs are usually identified with feedback/complaints from workers. The focus of the proposed research work is to identify the occurrence of such WERFs in selected industries and to implement specific ergonomic interventions in the shop-floor workstations to prevent or decrease the development of MSDs [7]. Capital intensive industries are usually well automated and therefore there is lesser scope of ergonomic interventions in such industries. Therefore, labour intensive industries are included in present work. There are a number of labour-intensive industries in Agra region which include footwear manufacturing units, petha making units, casting units, brick manufacturing units, glassware manufacturing units etc.

Literature Review

An exhaustive literature review was carried out. Here we present some of the more relevant and recent studies in brief. A multilayered ergonomic intervention program was demonstrated on reducing MSDs in an Iranian steel manufacturing unit [8]. MSDs are closely identified with common complaints in different workplaces. Intervention program included three layers, viz.,

training workshops, participatory ergonomics (PE), and workstation redesign for about 4 years starting from 2017. Results revealed a number of MSDs risk factors. The study concluded that a multifaceted ergonomic intervention program could be applied to enhance health and safety of workers and to improve productivity.

Shop floor workers are adversely affected by awkward working postures and body part discomforts. Work-related ergonomics risk factors were identified in a study to implement ergonomic design interventions in the workstations of a plastic furniture manufacturing industry [9]. Researchers used a number of tools and techniques including questionnaire study, postural assessment tools, computer aided design, digital human modeling, and work study. Virtual ergonomics evaluation of the workstation with some of the proposed accessories/fixtures demonstrated a reduction of awkward working postures. Physical prototypes of the proposed fixtures were constructed and real human trials were performed in the factories. Time study indicated reduction in operator cycle time when compared with time taken before design modifications.

A study on the usage of industrial robotic solution as an ergonomic intervention in a packing workstation in a furniture manufacturing industry was presented [10]. Workers of packing lines are exposed to several risk factors that can lead to occurrence of work-related MSDs. This study addressed the effectiveness of the implementation of a robotic aid in a packing workstation from an ergonomics viewpoint. The Nordic Musculoskeletal Questionnaire (NMQ) [11] was applied to workers of semi-automated packing lines. To assess, the RULA was also applied by trained ergonomists by analysing the packing workstations before and after the adoption of the robotic aid proposed solution. The finding revealed that trunk torsion was the most highlighted MSD risk factor by all workers. The obtained RULA scores demonstrated that the adoption of a robotic aid eliminated this risk factor and, consequently, reduced the corresponding MSD risk.

The effect of designing ergonomically assembly workstation on operator performance was investigated experimentally in a study. A fully adjustable ergonomically design reassembly workstation was used for the experiment. Three experimental factors (table adjustable, chair adjustable, and gender) were considered to perform the assembly task [12]. Performances of the participants assembling a product were measured. Operator productivity, operator satisfaction and operator health were the three

performance measures. The findings demonstrate that female subjects were more productive and healthier than male subjects but with lesser satisfaction.

Proposed Methodology

The framework of proposed methodology is presented below.

(i) Industrial Survey

This research work would begin with an industrial survey to study activities in shop-floor workstations of selected local factories from ergonomics viewpoints. Thereafter workstations would be marked to perform intended ergonomic analysis. Then NMQ [13] would be used to investigate the incidence of MSDs among workers of marked workstations. NMQ procedure involves showing a body map to workers/volunteers and elucidating responses to various queries [14].

(ii) Subject Selection

It is proposed to have two groups of subjects viz. (i) an experimental group and (ii) a control group. The presence of control group would allow us to confirm that study results are due to the manipulation of independent variables rather than extraneous variables. Control group comprise participants who are not exposed to the manipulated independent variables but are measured on the study's dependent variables. Since subject selection criteria such as age, gender, work experience, working condition, smoking habits etc. may influence task performance, therefore, these criteria would be defined before carrying out experimentation in the proposed research work.

(iii) Ovako Working Posture Assessment System (OWAS)

Shop-floor workers are adversely affected by prevalent awkward working postures and consequent body part discomforts. Work activities in marked workstations would be photographed and/or videoed for posture analysis. It is proposed to use Ovako Working Posture Assessment System (OWAS) [15-17] for evaluating the working postures. OWAS technique is employed to understand overall scenario of postures among workers during various activities [18-19]. We may use easily implementable accessories/fixtures with convenient design features to reduce awkward working postures. Physical prototypes of the proposed fixtures may be constructed, and real human trials can be performed in factories.

(iv) Digital Human Modeling

It is intended to use a digital human modeling (DHM) tool to generate virtual model of marked workstations. Actual dimensions can be measured at the factory site. An anthropometric database of adult Indian male population can be used to build digital human model for assessments. 5^{th}, 50^{th} and 95^{th} percentiles virtual male human model would correspond to smallest, average and largest dimensional adult Indian male population respectively. DHM helps to improve physical attributes in the workstation by generating a digital human (manikin) which may be inserted into 3D graphic representations of work environments. We would interface manikins with virtual version of marked workstations, featuring selected working postures using DHM tool. Existing workstation and work activities would be evaluated using digital human models representing 5^{th}, 50^{th} and 95^{th} percentiles Indian adult males for identifying postural comfort [20]. It is also intended to carry out a spinal load analysis using DHM tool. Compression and joint shear values are used to evaluate mechanical load of L4-L5 vertebrae in lumbar region of manikin for a given working postures. This analysis would help in assessing disorders of the lower back.

(v) Anthropometry

To enhance man-machine compatibility and to avoid poor working postures we should base the design of equipment, workplace, and product on anthropometry of concerning workers. For that we design for a range of population from 5^{th} percentile to the 95^{th} percentile encompassing smallest and largest body dimensions. Anthropometry data would correspond to male population, as most of the local factories employ male workers only. Accordingly, workstation and work methods would be assessed and modified suitably for male population. Practical low-cost improvements, validated with application of basic ergonomics principles in workstation design would be attempted.

(vi) Evaluating Psychosocial Work Environment

It is intended to evaluate the psychosocial work environment among the workers in the marked workstation using some standardized techniques such as Copenhagen Psychosocial Questionnaire (COPSOQ) [21]. The psychosocial work environment of experimental group subjects can be compared with that of control group subjects for arriving at conclusions. Further, it is intended to

use National Aeronautics and Space Administration-Task Load Index (NASA-TLX) [22] questionnaire to examine the subjective mental workload of the workers in the marked workstations and the control group.

(vii) Method Study

We also intend to carry out a method study to record and analyse work activities before and after workstation, work method design modifications. Time study technique is used as a tool for facilitating method improvement [23]. Occurrence of work-related MSDs is affected by work-pace and other factors like design of workstations [24]. Observed cycle time before and after suitable ergonomic interventions can serve as indicators for reduction in work-pace without compromising on productivity.

Work Schedule

The proposed research project schedule is explained in Table 1.

Table 1: Work schedule for the proposed research

Sr.	Activity	Time (Month)	
1	Data collection from different local manufacturing units		**6**
2	Experimental studies		**12**
3	Analysis of results		**6**
4	Detailed discussion of results and submission of research work in peer reviewed journal/conference		**6**
5	Thesis writing		**6**

Conclusion

Workers involved in repetitive jobs in workstations for a longer period in awkward postures are exposed to the risks of MSDs. Awareness programs, early diagnosis, and redesign of workstations are useful to alleviate or decrease the impacts of work-related MSDs and muscle fatigue. It is expected that methods and design solutions from an ergonomics perspective can serve as a helpful guide for local small and medium factories of industrially developing countries and for similar research endeavours.

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